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Knowledge Cultivating for Intelligent Decision Making in Small & Middle Businesses

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Abstract

Small and middle businesses (SMBs) are playing an increasingly important role, but their decision making process mostly relies on skilled employees which are usually inadequate. Based on information systems, data mining and Extension Theory (Extenics), we present a knowledge cultivating method and design a knowledge management platform for improve decision making quality. Through divergence analysis, correlation analysis, and implication analysis, a flow chart of knowledge cultivating algorithm has been designed, and an intelligent knowledge management platform has been developed. By collecting knowledge or information from conditions and the goal, we choose several knowledge as seed, then distribute it to all the department leaders, let them input relative knowledge including data mining knowledge to the platform. The platform then connects them into a knowledge tree with Human-Computer Interaction and enterprise ontology techniques intelligently. From the knowledge tree, we can find the problem solving map and guide the managers in SBMs to take actions by scanning all possible paths. The application in a food company proved its practicality value.

Keywords- intelligent knowledge mangament; knowledge cultivating; decision making; small and middle businesses; Extenics

1. Introduction

Small& middle businesses (SMBs) are playing more and more important role in economy. One of the SMBs' problems is that there are not enough wise and skilled employees to make right decisions when the problem occurs [1]. Most decisions are made subjectively by the boss, without considering other people's suggestions or some latent factors. The boss needs decision support urgently. Especially in the context of the financial crisis, the requirements of business-decision support system have been increasing. Several knowledge management platforms had been designed to improve the decision level [2-4]. However, the knowledge accumulating needs practice and time, some bosses can't keep waiting. The World Wide Web, information systems and other data set have constructed a huge information source for decision making, Information technology promoted the decision making in three major directions: "decision support, multiple criteria decision making, and data mining and risk analysis" [5]. Some

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systems support decision makers by multicriteria decision anglicizing [6] or various types of classifiers such as support vector machines (SVM), C4.5 algorithm, and K-nearest-neighbor algorithm [7]. To solve the problems of fuzzy multi-attribute group decision making, paper [8] presented a fuzzy dominance method for ranking trapezoidal fuzzy numbers based on the credibility theory and gray relative degree. With information be exchanged freely among several modules, paper [9] integrated macroeconomic early warning theories and a knowledge base to policy making process: monitoring, forecasting, and policy simulation, it can support the economic early warning and policy making process. All above methods or models can improve decision making intelligently to a certain extent, but they are not easy to be applied in SMBs, because there are usually few support environments and skilled employees.

Management information systems have been utilized in some SMBs, from which data mining, web mining or text mining [10-11] can discover knowledge from web pages or database. But there are also no sufficient skilled persons to handle them in SMBs. Even they can afford the project fee by cooperating with professional company, they usually can't get practical knowledge in a short time, the engineers need time to obtain the experience of the related fields and clean the data systematically [12]. So the result of input-output is usually not satisfied. Even the knowledge is discovered from data, this kind of new knowledge is huge and rough, not all the knowledge is useful in applications. For example, in a VIP email accounts analysis project, 420 rules were mined out from a data set of 16,496 records and 231 attributes by See 5 software, each rule is a kind of knowledge but only several rules are useful. The knowledge from data mining goes far beyond the traditional knowledge, so they can not be used efficiently.

Realizing the importance of post-processing on data mining results, some scholars had tried to make management of this kind of knowledge intelligently [13-15], and further more presented lots of frameworks for intelligent knowledge management [16-18]. But most of the researches have not yet been applied into practical use in SMBs. Computer assistance on solving problems is in many ways, as for SBMs, the most important thing is to provide clear and simple instructions to the decision makers [19]. Only a simple and practical way can help the boss to achieve wise decisions, which is in great demand.

The purpose of this paper is to propose a knowledge cultivating method for SBMs to optimize the process of decision making. By reporting the problem and collecting knowledge step by step, the knowledge accumulated and form a knowledge tree, from it we can find the relations between the information and knowledge, and then add human domain knowledge to the tree, the tree is growing and finally covers the larger area and solves the problem. The rest of the paper is organized as follows: Section 2 introduces the knowledge seeding technologies. Section 3 describes the algorithm and the process of knowledge cultivating. Section 4 presents a case study in a food company. Section 5 concludes the paper with future research directions.

2. Knowledge Seeding Technologies

Every enterprise has data, information or knowledge, special knowledge plays an important role in decision making process. But most SMBs just *own* them, instead of share it, update it and make benefit from it. The knowledge they owned usually is partial and local, only reflects a certain side of business. While intelligent decision making process must collect as much as knowledge and integrate it from different views to reach a complete understanding of the problem. So the first step to improve the decision level in SMBs is to obtain as much as knowledge and seed it for later use. Extenics [20] gives a way to collect information and knowledge systemically and gives series methods to utilize them. Meanwhile data mining gives a way to discover novel knowledge [11]. These two technologies can combine and will have a good fruit for decision support.

2.1. Extension Theory-- Extenics

Extenics is constituted of Element theory, extension methodology and extension engineering. It is a new discipline for dealing with contradiction problems with formulizing models [20]. To make wise decisions, we must consider the objects, the characteristics and the measure together. A matter has many characteristics. From the view point of material nature, every matter is the entity of the imaginary part and the real part. Similarly, each element has four extensibilities: the divergent nature, the conjugate nature, the correlative nature and the implicative nature. As to the conjugate nature, there are four pairs of conjugate parts including the real part (the entity of a matter's existence) and the imaginary part (the sprit of the element, such as brand of a product), the soft part (relation structure between parts of a system) and the hard part (each part in a system), the latent part (unnoticeable element or forthcoming change) and the apparent part (noticeable element), and the negative part (the part creating positive value to the goal) and the positive part (the part creating negative value to the goal). This gives a testing way to check whether we own systematic knowledge for intelligent decision making.

A matter can be expressed as an ordered triad

$$R = (N, c, v) \qquad (1)$$

R is the ***matter-element,*** N represents the matter, c is the characteristics, *and* v is the measure about the characteristics c.

Moreover, Extenics establishes matter-element $R = (N, c, v)$, affair-element $I = (d, b, u)$ and relation-element $Q = (s, a, w)$ (each has attributes or characteristics and their measure) to describe matter affair and relation. Matter-element, affair-element and relation-element are collectively called basic element. A matter has many characteristic-elements, which can be described by n-dimensional matter-elements.

$$M = \begin{bmatrix} N_m, & c_{m1}, & v_{m1} \\ & c_{m2}, & v_{m2} \\ & \vdots & \vdots \\ & c_{mn}, & v_{mn} \end{bmatrix} = (N_m, C_m, V_m) \qquad (2)$$

All information and knowledge related to the goals and conditions in decision making can be expressed as matter-elements. Extenics also presented transformation methods. By certain transformation, one thing that doesn't have property P can be turned into another thing that has the property P. Extension set can describe this kind of transformation quantitatively. So the extension field can be recognized as a set of things that doesn't have the property P but can be changed into those with the property P [21]. Up to now a series of particular extension methods have been developed and applied in various fields [20].

2.2. Data mining technology

Data mining discovers knowledge and rules from large numbers of data. They are connotative, unknown, which are likely to be interested, and to have latency values for decision-making [10-11]. Today data mining has been widely accepted. But for SBMs, to organize a data mining project is not easy. Data mining process can be divided into six phases [22]: business understanding, data understanding, data preparation, modeling, evaluation, and deployment. These phases can help SBMs understand the data mining process and provide a road map to follow while planning and carrying out a data mining project. But in SBMs, data quality is low, data cleaning often cost much time [12]. In order to collect enough information for decision making intelligently, we must have enough source with good quality, and then have tools and methods to extract information or knowledge from them.

There are many data sources in the information age. Besides information systems, The World Wide Web has also become a common and huge information source. Billions of pages are publicly available and it is still growing dramatically every day. Data mining is a useful tool for mining constriction knowledge from data base, text files and the web. Combining Extenics with data mining, a new methodology called Extension data mining (EDM) [23] has been build up. The main task of EDM is to acquire the transformation knowledge to help for better decisions. It takes advantage of extension methods and data mining technology, explores to acquire the knowledge based on extension transformations.

Web mining and text mining can discover lots of knowledge from huge amounts of web pages, including web documents, hyperlinks between documents, usage logs of web sites, and local text files, public database etc [10]. Meanwhile EDM can acquire extensible classification knowledge, conductive knowledge. Such kinds of data, information and knowledge gathering together, we have to do deep research on how to select proper knowledge for decision making from them.

2.3. Knowledge Seeding method

The mean purpose of knowledge management and data mining is to aid people make wise decisions and finally solve problems. Many problems are in latent status or just show its surface, so find the problem is the beginning. Usually bosses or higher leader can find some problems in the company, data mining or information analysis can help department leaders find the same problems too. All problems can be expressed as information, and among them there must exists certain knowledge as the key to the problem solving.

The process to write the relative knowledge to the problems is called knowledge seeding. The primary relative knowledge is called seed knowledge. The process to find the key knowledge from seed knowledge is called knowledge cultivating.

Finding seed knowledge start from the problem $P = G * L$, when the condition L can not enable the goal G to come true, then P is called the incompatibility problem [21], G and L can be expressed with basic-elements, the operational formulas of basic-elements or complex-elements. Accordingly, seed knowledge can be classified into two types: one is relative to conditions L; one is relative to the goal G.

G and L can be expressed with basic-elements, the operational formulas of basic-elements or complex-elements. Suppose c_{01}, c_{02}, …, c_{0m} are evaluating characteristics of P, $P_0 = g_0 * l_0$ is the core problem of P [21], where

$$g_0 = \begin{bmatrix} Z_0, c_{0s1}, X_{01} \\ c_{0s2}, X_{02} \\ \cdots\cdots \\ c_{0sm}, X_{0m} \end{bmatrix}, \; l_0 = \begin{bmatrix} Z_0, c_{0t1}, c_{0t1}(Z_0) \\ c_{0t2}, c_{0t2}(Z_0) \\ \cdots\cdots \\ c_{0tm}, c_{0tm}(Z_0) \end{bmatrix} = \begin{bmatrix} Z_0, c_{0t1}, x_{01} \\ c_{0t2}, x_{02} \\ \cdots\cdots \\ c_{0tm}, x_{0m} \end{bmatrix} \quad (3)$$

c_{0s1}, c_{0s2}, …, c_{0sm} are the necessary characteristics about c_{01}, c_{02}, …, c_{0m} when G comes true, their measure ranges are X_{01}, X_{02}, …, X_{0m}. c_{0t1}, c_{0t2}, …, c_{0tm} are the characteristics supplied by Z_0, which is an object basic-element in L, about c_{01}, c_{02}, …, c_{0m}, their measures are $c_{0t1}(Z_0)$, $c_{0t2}(Z_0)$, …, $c_{0tm}(Z_0)$. Let

$$W = \left\{ l \,\middle|\, l = \begin{bmatrix} Z, c_{0t1}, c_{0t1}(Z) \\ c_{0t2}, c_{0t2}(Z) \\ \cdots\cdots \\ c_{0tm}, c_{0tm}(Z) \end{bmatrix} = \begin{bmatrix} Z, c_{0t1}, x_1 \\ c_{0t2}, x_2 \\ \cdots\cdots \\ c_{0tm}, x_m \end{bmatrix}, Z_0 \text{—} | Z \right\} \quad (4)$$

Seed knowledge is most relative to the core problem P_0. According to Extenics, there are three main methods to find seed knowledge:

1. Divergence analysis - based on divergent of base element.

$$R = (N, c, v) -| \{(N, c_1, v_1), (N, c_2, v_2) ..., (N, c_n, v_n)\} \quad (5)$$

-| represents divergent directions.

2. Correlation analysis - based on the relevance of base element.

If $c_0(B_2) = f[c_0(B_1)]$, and $c_0(B_1) = f^{-1}[c_0(B_2)]$, then we named B_1 and B_2 is relative based on attribute c_0, noted as $B_1 \sim B_2$.

3. Implication analysis - based on implitility of base element.

A implies B means that "If A, then B", written as

$$A \Rightarrow B \quad (6)$$

The above relation between A and B is called *the implication relation*, which can exist among matters, characteristics, measure, characteristic-elements and matter-elements. The elements B_1, B_2, …, B_n and the implication relation among them constitute an implication system B.

Data mining also can discover novel knowledge from data base as seed knowledge. Knowledge discovered from data may take many forms, such as equations, contingency tables, taxonomies, decision trees, rules, graphs, concepts, exceptions from patterns, and many others. Knowledge entity and its meta-data can be represented by matter-element too. in general, the knowledge seeding method is shown in Fig 1.

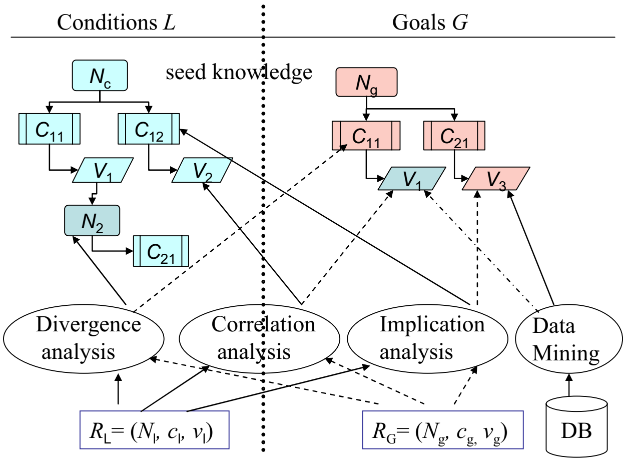

Fig. 1.knowledge seeding method

3. Knowledge cultivating Method and its Process

From seed knowledge to the solution is a long way. Most of times, we can not find the solution mainly rely on employee's experience, that's why problems everywhere. The boss is too tired to solve all problems, so he organizes his/her subordinates to make decisions together. Multi-person decision making process involve the preferences of some experts about a set of alternatives in order to find the best one. However, sometimes experts might not possess a precise or sufficient level of knowledge and as a consequence that expert might not obtain all the information that is required. Studied on incomplete information situations, paper [24] designed several procedures that can compute the missing information of a preference relation and analyzed several strategies to deal with these situations. Essentially, what most scholars did is to complement the knowledge what decision making need.

According to a detailed information collecting list [25], we can complement comprehensive information and knowledge for intelligent decision making. With the information cube [25], we can collect the integrated information from the web or other data sources systematically. Then we can take advantage of extension method to let seed knowledge grow up according to the extensibility of basic-element. These will greatly improve the intelligence level of decision making in SMBs.

3.1. Key Processes for Knowledge cultivating

There are as many methods for knowledge cultivating as for data mining. The purpose of decision making is to find the way to the goal we expect. And the way relies on information and knowledge we have owned. The problem is that we sometimes can't tell the way when we are faced with so much information and knowledge. So the most practical method of knowledge cultivating is to find the relations between them and form knowledge net.

There are three ways to solve an incompatibility problem: (1) the goal doesn't be changed, a contradiction problem can be solved through changing its conditions; (2) the conditions don't be changed, a contradiction problem can be solved through changing its goal; (3) the contradiction problem can be solved through changing both its goal and conditions at the same time [20]. Whatever the way we choose, we can establish an extension set using the measure as quantity fields. And then we can let knowledge grow by divergence analysis and extension transformations. When the knowledge tree grows big enough, some ones can change an incompatibility problem into compatibility one.

Based on the above analysis, we designed a framework of Extension theory based knowledge cultivating process as in Fig 2. The process of cultivating seed knowledge to knowledge tree has six main steps by man-computer cooperative methods.

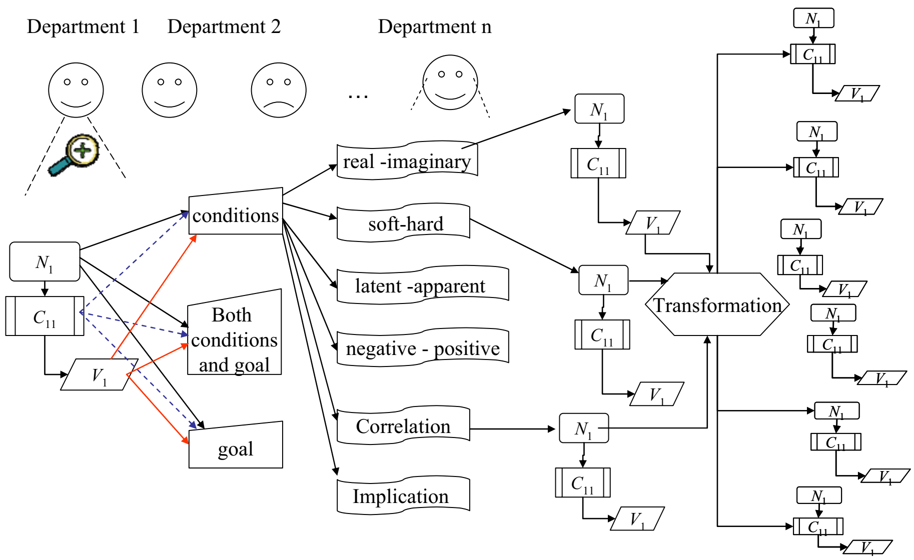

Fig. 2.knowledge cultivating methods and its process

Step 1, Distribute business problems and their condition-goal information with knowledge seed to all departments of the company on a sharing platform. The platform can be web site or management system or other BBS et al.

Step 2, Add information or knowledge related to the problems to the above platform. The information or knowledge should cover the real part and the imaginary part, the soft part and the hard part, the latent part and the apparent part, and the negative part and the positive part. In addition, correlation analysis and implication analysis are used to find the cause, the relation net et al. These will make sure that the problem is been considered systematically.

Step 3, Connect information or knowledge by element name or it characters and measure. Clip redundant information or knowledge. A knowledge clustering will appear. This step can be implemented by software, which needs support of ontology base.

Step 4, Evaluate the clustered knowledge and select the feasible ones to make transformations. The transformations methods include replacement T_r, decomposition T_d, increasing or decreasing T_l , and expansion or contraction T_e, which are four basic transformations of matter-elements [20].

Step 5, Through above steps, we have formed a lot of knowledge trees, add human experience knowledge to connect them to be a whole knowledge tree.

Step 6, Judge if the tree can help make decisions and solve the problem. If not, we can collect much more information from it in next loop. If yes, store the main path into solution base and share it to managers.

If a transformation T_W (or T_K or T_l) can not solve an incompatibility problem, we can consider conductive transformations of these transformations.

3.2. Knowledge tree and its implementation

Though the above process, the SBMs will calculate a lot of knowledge on some problems, so a software platform is necessary to manage them efficiently. So we designed a structure to store knowledge tree and form an enterprise ontology base [26]. Then we designed the data base with its tables, proposed an algorithm as showing in Fig 3.

In the algorithm, we first locating the problem expressed with base element, then collect information and knowledge especially from data mining. We select knowledge as seed, cultivate it based on ontology or basic element base. Then we judge if the knowledge tree grows to meet the goal, if not, maybe add more experience knowledge by human-computer interaction. Loop until meet the need of decision makers.

Finally a management system is developed to support knowledge seeding and cultivating process. Through the platform we can get a map of how to achieve goal by a certain knowledge tree. The tree is shown in Fig 4 as follows:

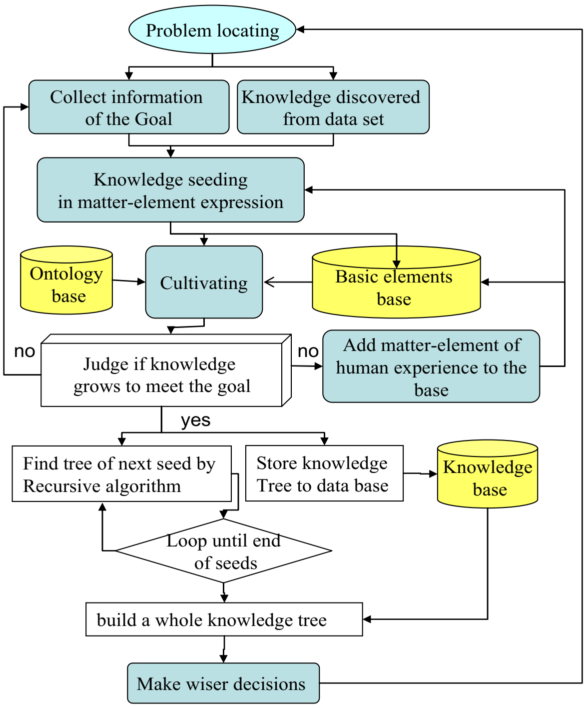

Fig.3. Flow chart of Knowledge cultivating algorithm

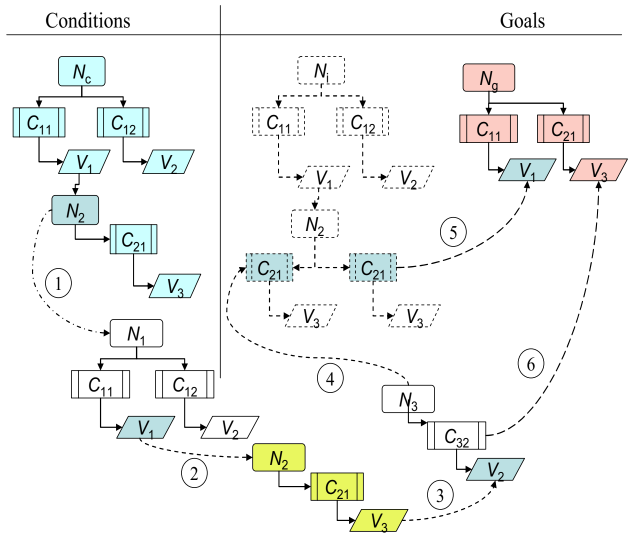

Fig.4. Knowledge cultivating from a knowledge tree

The knowledge tree is consisted of kinds of information and knowledge comes from many departments or even from data mining. Every one's experience is limited, by integrating many employees knowledge by information technology, it is possible for ordinary people make right decisions and solve the problems formerly only the boss can do. From the tree, we can also understand the path from conditions to the goal, and find the answer like which knowledge is the key factor or which one is the essential reason of the problem. With such knowledge accumulated to an extent, the decision level in SMBs will arise day by day.

The detailed description is shown in the following case in section 4.

4. Case Study

A food company in north China produced a new kind of drinks in almond like coffee. The distribution of its orders is very uneven; generally, the average order cycle is 7 to 27 days. Besides, through data mining, we found that 95% orders are more than 420 boxes. Almost every order requires the products made in 7 days and delivered hopefully within 4-6 days.

The maximum safety stock of semi-finished products in its workshop is only for 120 boxes and the products can be produced 20 boxes per day. Even the two lines in factory can run all the time, only made 140 boxes of products in 7 days, how can we arrange production lines to meet the order needs? If we install one more produce line, and hire more employees, most of time the resource is in idle. The profit therefore is decreased or even loss. Their goal is that the factory can produce evenly, but the store can meet the order needs without build new lines or hire more people.

After the seed knowledge is put forward, the company made knowledge cultivating as following:

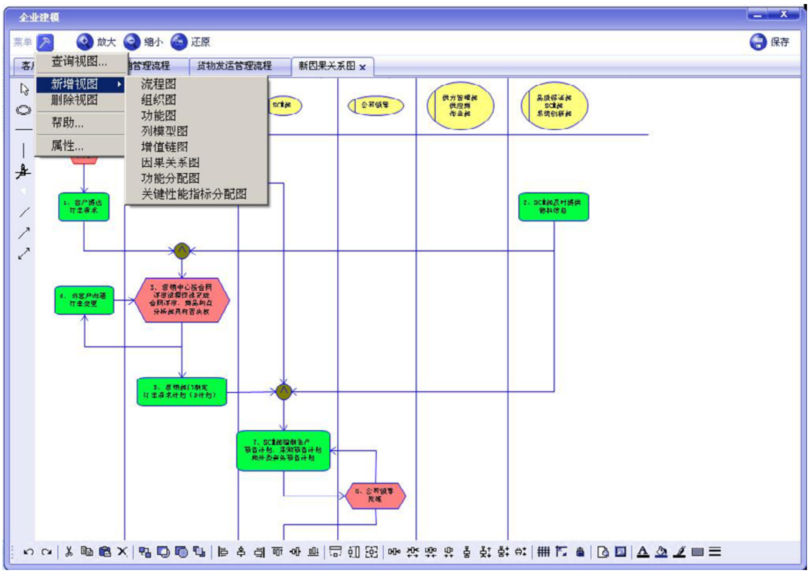

Fig 5 the main window of knowledge cultivating software platform

(1). Implication analysis: Why is the general weight of every order about 420 boxes? Why are they required newly produced products in the last week and delivered so quickly within 4-6 days?

(2). The sales department offered a sales policy that the minimum order of 200 boxes every time is required. So the order of less than 200 boxes is forbidden. Another policy they added is that the dealer can enjoy 10% discount if an order with more than 400 boxes, and if an order is more than or equal to 600 boxes, the dealer can enjoy 15% discount. Generally there are 2 to 3 dealers for each sales region and in order to get price concessions they prefer order 400 boxes of products.

(3). The marketing department informed that the new sales region needs to distribute products and the random of these new shops' orders is large, so it is difficult to predict the date of orders in the expansion period.

(4). Why did the products require to be produced in the last week and delivered hopefully within 3 days? The logistics department reflected that dealers often need 5 to 6 months to sell out 400 boxes of products, and the shelf life is 6 months and consumers like to buy the products of the latest production date, so if the products ordered produced in 3 weeks, there is high probability that expired products are scrapped. As a result, dealers always try to get products produced recently.

(5). The dealers said if new products are delivered while the old ones are not sold out, it will be more difficult for the old ones to be sold because consumers always choose the new, so dealers always order when it's almost out of stock. Besides, if the products can't be delivered during seven days, there may be lack of products. Taking into account 3 days' transport time and 2 days' insurance period, there are only 4 days for delivery, which is the reason why dealers attach importance to delivery time.

By transform production conditions, the boss think it's too low that daily produce capacity of the equipment is only 20 boxes per day. He asked the workshop director to improve produce capacity. By changing the combination of team members, daily capacity can increase to 23 boxes per day without additional equipment and personnel. In accordance with the knowledge cultivating, they take transformations as following:

Firstly, decompose the sales policy: from "if an order is more than 400 boxes, the dealer can enjoy 10% discount" to "if the orders are sum up to 400 boxes in half a year, the dealer can enjoy 90% discount" and the minimum quantity of each order changes from 200 boxes to 10 boxes.

Secondly, they cooperate with many small logistics, and can transport 10 boxes of products to the dealer in 2 days. The delivery date and the demands of production date reduce accordingly. The main window of knowledge cultivating system is shown in Fig 5.

After the extension transformation above, the problem changes: Small orders arrive continuously, the enterprises' production capacity is balanced, the expired loss of products in the shop drops to the minimum. Customer satisfaction increases and competitiveness to develop new markets improves.

The knowledge-cultivating algorithm works on the existing conditions to find optimal solution. In this process, the condition transformation may have to be cycled several times and each time the conditions are re-transformed. The condition transformation includes implication analysis, interpersonal communication, negotiation et al. We have to analysis results, discuss and analyze the reasons. Therefore, it is a systematic algorithm for human-computer interaction in SMBs, which integrate human system and software algorithms, so that humans can get transformation methods with the help of extension methods to achieve a wiser decision-making level.

5. Conclusions and Future Study Directions

In the era of knowledge economy, information and knowledge has become an important resource. Knowledge discovered from data mining can support SMBs to improve decision-making level by our knowledge cultivating method. The method integrates Extenics, data mining and knowledge management, and can develop a decision support system platform. By collecting knowledge or information from conditions and the goal among all departments in SBMs, this platform can share knowledge from every employee in varies forms. Knowledge or information related to the conditions or goals of the problem can find relations by human-computer interaction method. Divergence analysis, correlation analysis and implication analysis have been used in the platform and proved useful to extend knowledge reference range. Then it forms the knowledge tree, in which the problem-solving map can guide the managers to take actions by scanning all possible paths. A simple intelligent knowledge management platform can support decision-making process efficently in SMBs.

But the algorithm we used in the paper is relatively simple, the knowledge mapping process need to be improved more intelligent so as to remind what kind of information should be supplied. On the other hand, knowledge and information can even reasoning and produce new knowledge. How to update ontology automatically and simulate the knowledge cultivating process by intelligent agent is the next research work. Moreover, Fuzzy set, complexity Science and social agent technology will be utilized to improve the platform.

Acknowledgements

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